THE STRUCTURE OF HAILSTONES.

By D. S. LANDIS, Assistant Observer. Dated Fort Worth, Tex., July 11, 1906.

On the evening of the 20th of June the observer at Fort Worth had an unprecedented opportunity to examine hailstones with reference to the formation of the centers. The hail fell for fifty minutes, and the stones were plentiful for several hours after the storm had passed. The hailstones of this storm were very symmetrical, the prevailing form being an oblate spheroid about two and a quarter inches in the long diameter by one and three quarter inches in the short axis. The largest stones had nine definitely marked concentric layers outside of the central nucleus. Three other styles of formation were in evidence, viz, those having three, five, and seven layers. These layers were distinguishable by being cemented, or congealed, together by sheaths of a thin white amorphous ice so devoid of thickness as not to be called a layer, yet in the cross sections the lines of separation were as well marked as those of the layers of an onion.

It was noted that every stone had an odd number of layers in its formation, the series running three, five, seven, or nine layers. The outside surfaces of all stones were quite smooth and of crystal ice. In the seven- and nine-layer hailstones the layer next to the surface layer was snowy, something of the nature of a snowball dipped into water and slightly compressed, forming a sort of mushy amorphous ice, usually very white. In the five-, seven-, and nine-layer formations, the third layer, counting from the nucleus outward, was an enwrapment of snow so definite in structure as to admit of no doubt of its being moist snow. This third layer was about as thick as heavy blotting paper. In the seven- and nine-layer formations the nucleus and all layers were crystal ice, excepting the third and the layer next to the surface layer.

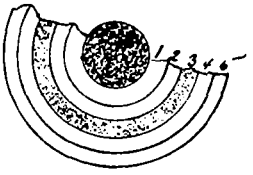

FIG. 1.

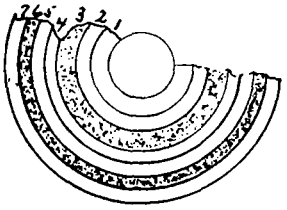

FIG. 2.

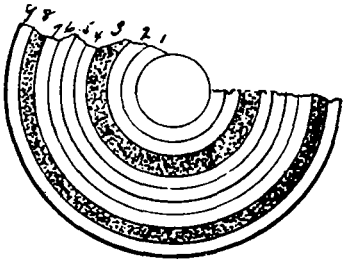

FIG. 3.

Figs. 1, 2, and 3 show the formations of hailstones having five, seven, and nine layers, respectively, outside the central nucleus. The stippled dark portions represent snow of a definite form, granular in a few instances, but not compact, as amorphous ice usually appears.

In the five-layer formations there were variations from the seven- and nine-layer stones, i.e., the five-layer formations always had a soft center or nucleus of either amorphous ice or snow. In two instances the centers presented such feathery frost needles that the contents could be shaken out by gently tapping the ruptured stone with a lead pencil, leaving a spherical cup of crystal ice, ragged and pitted within.

Another feature of this hailstorm, probably having some significance with reference to the altitudes at which these hailstones had been formed, was that at intervals of about ten seconds from the time a loud peal of near-by thunder was heard there would be a downpour of nine-layer hailstones, followed two seconds later by an increased shower of the seven-layer formations, and one second after these came the five-layer formations, immediately followed by the small three-layer pellets of ice.

During the storm the wind was blowing a gale, and the direction of descent of all stones was the same, except for the nine-layer formations. At intervals only, these came from a direction almost opposite to the course of the wind; the remainder of the time they came quartering with the wind. During the reverse action of the stones against the wind the descent was at an angle of about 60°, but at other times the descent was more nearly perpendicular.

The test for the presence of air within the stones showed that whenever a snowy or amorphous ice layer was reached air bubbles were in evidence. No air bubbles were given off from the three-layer stones, nor from the centers of the seven- and nine-layer formations. Whenever the five-layer centers were reached air bubbles were present, plainly showing the presence of enlocked air.

The snowy centers of the five-layer formations seem to have originated in a snow zone. The other nuclei must have been formed without the snow zone. The snowy layers, or amorphous ice conditions, noted in the seven- and nine-layer formations, indicate that the snow zone must have been passed twice.

In view of the observations made during this hailstorm it seems wrong to assert that the center of a hailstone is either crystal ice, or amorphous ice. It seems that the centers, or nuclei, are variable quantities, dependent upon the conditions of temperature and moisture, and the altitude at which the nucleus forms. With these factors in mind it is evident that the center of one stone might be crystal ice, another be amorphous ice, or mushy, like snow, while others can be dry snow, damp snow, or even frost itself.

By WELLINGTON SMITH. Dated Mifflintown, Pa., July 28, 1906.

We had a very severe hailstorm on Saturday, July 28, at 5 p. m. The stones were quite small at first, but at the end of twenty minutes they became large. They were flat and oblong, regularly corrugated from the center toward the circumference. They were from one inch to two inches in their longest diameter, and less, by one-third to one-fourth of these dimensions, in their shortest diameter. They were from one-half to three-fourths of an inch thick. They all were dished, or hollowed, toward the center, and some had holes. We gathered about a dozen stones from the board walk and placed them in ordinary pump water, but no one could see any bubbles ascend. Then we gathered some that fell on the heavy grass of the lawn, and these in a few minutes gave up very small bubbles. We then placed some more in a number of vessels of water, and bubbles were seen to ascend rapidly to the surface of the water. Most of these bubbles were exceedingly small, not larger than a grain of eagle powder, but I noticed quite a number as large as a common pin head. There was no mistake about the ascending bubbles of air, as every one in the house observed them.

The Fitchburg Sentinel of June 4 contains an account of a remarkable hailstorm occurring in the southern part of the town of Fitzwilliam, N. H., on Saturday afternoon, probably June 2. The storm cloud approached from the south about 4 p. m. Heavy rain, thunder, and lightning accompanied the hail. As the storm progressed the hailstones steadily increased in size, until at the end of ten minutes they were two inches in diameter. At 4:30 p. m. the storm was over, and observers began collecting the hailstones, which were generally either egg-shaped or round. Seventeen such stones filled a quart measure. The larger stones were buried their full depth in the earth. Most of the stones, if not all, had large, pure white, snowy nuclei, surrounded by a ring of transparent ice that was exceedingly hard.

The center of the storm seemed to be over a hill near Laurel Lake, as the hailstones were smaller in other parts of the town. From a cottage on this hill the observer seemed to see the southwest wind drive the storm toward Wachusett Mountain, 25 miles southeast, then a countercurrent of east wind blew the cloud back directly toward the hill and the cottage; and the sultry afternoon was followed by the storm, which began with cool winds from the southeast and the northwest at almost the same time.

Hailstones having very interesting corrugations are pictured in the MONTHLY WEATHER REVIEW, for April, 1877. (See fig. 4.) These fell at Morgantown, W. Va., April 28, 1877; they were about two by one and one-half inches, and the average volume was 0.873 cubic inch.

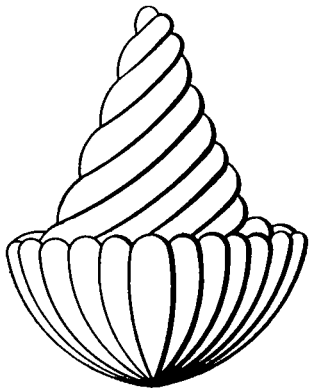

FIG. 4.—Corrugated hailstone.

—*C. A.*

SUGGESTIONS TO OBSERVERS OF HAILSTONES.

In connection with the excellent article by Mr. Landis it may be added that future observers of large hailstones should, if possible, note the following points:

1. Examine many nuclei and ascertain what proportion of them are (*a*) clear ice, (*b*) dry snow crystals, (*c*) a mushy mixture of snow or ice with or without air bubbles.

2. Devise some method of approximately measuring the temperature of the nucleus, as distinguished from the outside layer. The difference of temperature between the inside and outside may be quickly ascertained by thermo-electric methods. The average temperature of a whole hailstone, as well as of its several parts, can be determined by delicate calorimetric methods.

3. Measure the volumes of the successive layers and the nucleus. This is best done by making careful drawings of sections of the hail before it melts, and measuring from these drawings afterwards at leisure.

4. Observe whether the air bubbles in the respective layers are elongated radially, or have any other systematic arrangement.

5. Note the time which elapsed between lightning and thunder and the fall of hail, if any, apparently attending them; the connection is undoubtedly purely accidental, and the observations should bring out this fact.

6. Split the hailstones carefully with a sharp knife and note whether they have special planes of easy cleavage.—*C. A.*

WEATHER BUREAU MEN AS EDUCATORS.

The following lectures and addresses by Weather Bureau men have been reported:

Mr. Joseph L. Cline, June 12, 1906, on "Elements of the Earth's Atmosphere"; also June 27, on "Electricity, Atmospheric Disturbances, Weather Forecasting, and the General Work of the U. S. Weather Bureau", illustrated with stereopticon views, both before the Summer Normal School, Corpus Christi, Texas.

Mr. P. Connor, April 10, 1905, at the monthly dinner of the Kansas City Implement and Vehicle Club, on "Weather Bureau Work"; also June 9, 1905, before the Kelvin Club of the Central High School, on "The Weather Bureau, Storms, and Forecasting"; also November 16, 1905, before the Technological Society of Kansas City, on "The Equipment of Stations, Weather and Weather Forecasting"; also December 12, 1905, before the Bancroft Club, on "Climate and the Weather"; also February 9, 1906, before the teachers and pupils of the High School, Kansas City, Kans., on "Weather Topics"; also April 11, 1906, before the Athenæum, on "The Success of Weather Forecasting".

Mr. D. A. Seeley, October 26 and 27, 1905, before a class of 40 students in physics, Bradley Polytechnic Institute, Peoria, Ill., on "The Barometer".

Mr. A. H. Thiessen, June 27, 1906, before the class in geography, at the Summer School, State Agricultural and Mechanical College, Raleigh, N. C., on "The Weather Map and Forecasting the Weather".

Classes from colleges, schools, academies, members of teachers' institutes, etc., have visited Weather Bureau offices, to study the instruments and equipment and receive informal instruction, as reported from the following offices:

Buffalo, N. Y., June 5 and 6, 1906, a class of 38 students from the Teachers' Training School No. 10.

Evansville, Ind., June 12, 1906, the graduating class of the Baker Avenue Public School.

Kansas City, Mo., April 15, 1905, pupils and teachers from the High School, Argentine, Kans.; June 6, 1905, a class from the Central High School; October 24, 1905, a class from Loretto Academy; October 24 and 25, pupils from the High School, Kansas City, Kans.; January 20, 1906, principals of local schools; April 24, 1906, some of the Sisters and a large class from Loretto Academy.

Moorhead, Minn., June 30, 1906, pupils of the local Summer School.

Oklahoma, Okla., June 22, 1906, about forty members of the Oklahoma County Teachers' Institute.

Peoria, Ill., August 29 to September 1, 1905, 75 teachers, attending a local teachers' institute; November 6, 1905, a class of 12 students from Knox College, Galesburg, Ill.; May 2, 1906, the "As You Like It" Club of Peoria; June 15, 1906 (the annual "Open Night" at the Bradley Polytechnic Institute), more than a thousand persons.

Raleigh, N. C., June 28, 1906, geography class from the Summer School, Agricultural and Mechanical College.

Sioux City, Iowa, January 16 and 17, also June 7 and 8, 1906, classes from the Sioux City High School, in all about one hundred fifty pupils.

Vicksburg, Miss., June 27, 1906, the junior and senior classes of the Vicksburg High School.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

H. H. KIMBALL, Librarian.

The following titles have been selected from among the books recently received, as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies. Most of them can be loaned for a limited time to officials and employees who make application for them.

American Climatological Association.
Transactions. xxxi, 218, lx pp. 8°. Detroit. 1905.

Chile. Servicio Meteorolojico de la Direccion del Territorio Maritimo.
Anuario. 1904. 390 pp. 4°. Valparaiso. 1905.